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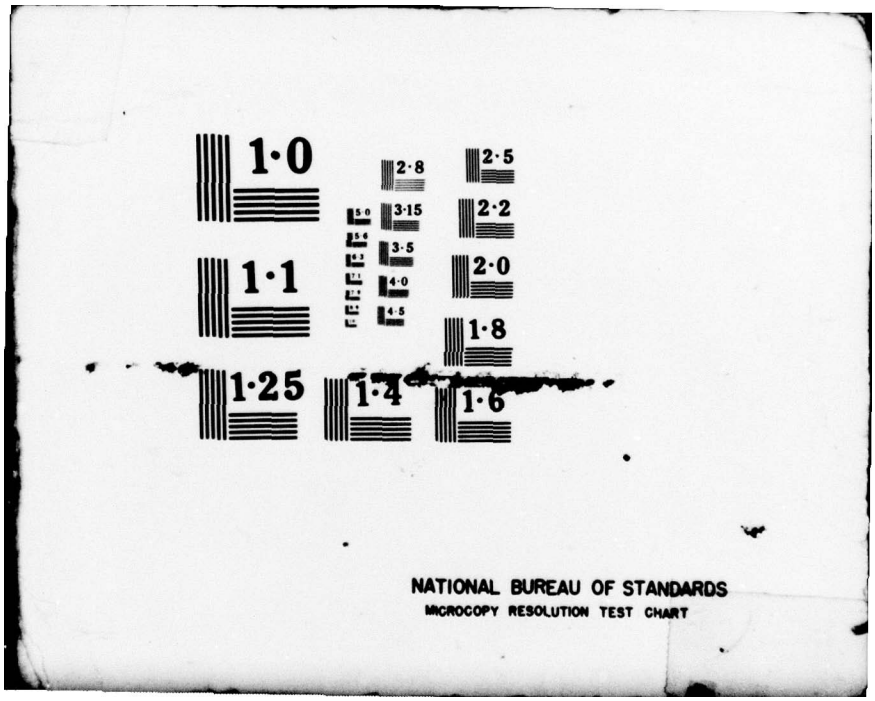
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A FUNDAMENTAL INVESTIGATION OF A HYBRID TECHNIQUE FOR GENERAL ELECTROMAGNETIC SCATTERERS AND ANTENNAS

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This report briefly summarizes the work on ONR Contract N00014-76-C-0573 from 1 February 1976 to 31 January 1979. The general purpose of this three year effort was to develop theoretical/numerical methods for the solution of electromagnetic problems. Of particular interest in this work was the continued development of the hybrid technique which combines the moment method treatment of wire antennas with the GTD for large conducting surfaces.

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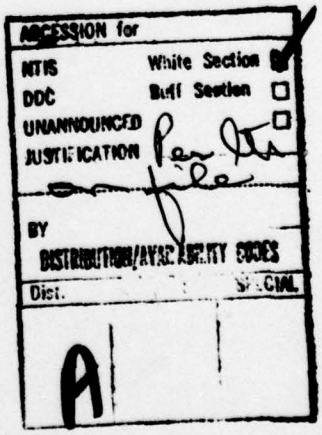

I. INTRODUCTION

This final report summarizes the accomplishments on ONR Contract N00014-76-C-0573 from 1 February 1976 to 31 January 1979. The general purpose of this three year effort was to develop theoretical/numerical methods for the solution of electromagnetic problems. A number of topics have been considered during the course of this research program, they are:

1) The extension of the hybrid technique which combines the moment method treatment of wire antennas with the Geometrical Theory of Diffraction, to include the GTD for curved surfaces. This method uses the GTD to extend the use of the moment method.

2) The use of the moment method to extend the use of the GTD (in contrast to the hybrid technique above).

3) The use of the moment method to develop a method for analyzing slot antennas, particularly in an array environment, with eventual incorporation into the hybrid techniuqe.

4) The development of general procedures for the optimization and synthesis of wire element arrays.

The major efforts on this research program have been on items (1) and (3) above. Most of the work on item (2) and all of the work on item (4) was performed by a University Postdoctoral Fellow, Dr. John Sahalos, who was supported by university funds.

Each of the above four topics has resulted in technical reports and also journal papers which either have been published, have been written but not yet published, or are being written at the close of the contract. In addition eight presentations have been made at various national and international symposia and two graduate students performed their PH.D. research while on this research program. These various accomplishments are listed in the next section.

II. PUBLICATIONS

Technical Reports

4372-1 "Optimization Methods for Arrays of Nonparallel Wire Antennas," by J. Sahalos, March 1977.

4372-2 "An Improved Formulation for Extending the Geometrical Theory of Diffraction by the Moment Method," by J. Sahalos and G. A. Thiele, May 1977.

4372-3 "Synthesis and Optimization for Arrays of Nonparallel Wire Antennas by the Orthogonal Method," by J. Sahalos, June 1977.

4372-4 "Bistatic Scattering by a Triangular Pyramid," by J. Sahalos and G. A. Thiele, June 1977.

4372-5 "A Hybrid Technique for Combining the Moment Method Treatment of Wire Antennas with the GTD for Curved Surfaces," by E. P. Ekelman, Jr., and G. A. Thiele, July 1978.

4372-6 "Computer Program for Thin Wire Antennas Mounted on a Satellite Body Modeled by Flat Plates," by D. L. Doan, G. A. Thiele and G. Chan, December 1978.

4372-7 "Moment Method Calculation of Reflection Coefficient for Waveguide Elements in a Finite Planar Phased Antenna Array," by A. J. Fenn, G. A. Thiele and B. A. Munk. September 1978.

Symposia Papers

"Reflection Coefficient Calculation for a Probe-Fed Cavity-Backed Slot Antenna," 1977 URSI/AP-S International Symposium, Stanford, California, June 22-24, 1977. Co-authors A. J. Fenn and G. A. Thiele.

"The Hybrid Technique for Combining the Moment Method Treatment of Wire Antennas With the GTD for Curved Surfaces," 1977 URSI Electromagnetic Wave Theory Symposium, Stanford, California, June 20-24, 1977. Co-authors, E. P. Ekelman, Jr. and G. A. Thiele.

"An Improved Formulation for Extending the GTD Using the Moment Method," 1978 URSI Meeting, Boulder, Colorado, January 9-13, 1978. Co-authors, J. Sahalos and G. A. Thiele.

"Moment Method Calculation of Reflection Coefficient for Probe-Fed Cavity-Backed Slot Antennas with Applications to Small Phased Arrays," 1978 AP-S/URSI International Symposium, University of Maryland, May 15-19, 1978. Co-authors, A. J. Fenn, G. A. Thiele, B. A. Munk.

"A Hybrid Technique for Combining the Moment Method Treatment of Wire Antennas with the GTD for Curved Surfaces," 1978 URSI/AP-S International Symposium, University of Maryland, May 15-19, 1978. Co-authors, E. P. Ekelman, Jr. and G. A. Thiele.

"An Overview of Two Methods which Combine the Moment Method and Asymptotic Techniques," XIX General Assembly of URSI, Helsinki, Finland, August 1-8, 1978. Author, G. A. Thiele. (Invited Paper).

"Moment Method Calculation of Reflection Coefficient for Waveguide Elements in a Finite Phased Array," 1978 International Symposium on Antennas and Propagation, Sendai, Japan, August 29-31, 1978. Co-authors, A. J. Feen, G. A. Thiele, B. A. Munk.

"An Improved Formulation for Extending the GTD Using the Moment Method," 1978 International Symposium on Antennas and Propagation, Sendai, Japan, August 29-30, 1978. Co-authors, J. Sahalos and G. A. Thiele.

Journal Papers

"Synthesis and Optimization for Arrays of Nonparallel Wire Antennas by the Orthogonal Method," by J. Sahalos, IEEE Trans. Ant. and Prop., AP-26, November 1978.

"Moment Method Analysis of Finite Planar Phased Antenna Arrays," by A. J. Fenn, G. A. Thiele, B. A. Munk. Submitted to IEEE AP-S, December 1978.

"On Extending the Hybrid Technique to Include the GTD for Curved Surfaces," By E. P. Ekelman, Jr. and G. A. Thiele. (In preparation.)

"A Comparison of the Transmission Line Model for the Folded Dipole with the Moment Method," by G. A. Thiele and E. P. Ekelman, Jr. (In preparation.)

"Improved Formulas for the Directivity of Vee Dipoles," by G. A. Thiele and E. P. Ekelman, Jr. (In preparation.)

Ph.D. Dissertations

"A Hybrid Technique for Combining the Moment Method Treatment of Wire Antennas with the GTD for Curved Surrfaces," E. P. Ekelman, Jr., degree awarded August 1978.

"Moment Method Calculation of Reflection Coefficient for Waveguide Elements in a Finite Planar Phased Antenna Ray," A. J. Fenn, degree awarded August 1978.

III. SUMMARY

As noted in section I, the major effort on this research program has been: (1) on the extension of the hybrid technique to curved surfaces, and (2) on the development of a moment method technique for the analysis of slot antennas with a view towards incorporating the slot work into the hybrid technique.

The progress on the first item has been most gratifying. During the course of this work it was found that the near field from a wire with a piecewise sinusoidal current could be cast into ray optical form (i.e., no radial component) if the field were treated as arising from point sources located at the ends of each wire segment. The piecewise sinusoidal expansion function is possibly the only expansion function that readily permits this to be done. This discovery is quite significant because it permits the hybrid technique to yield excellent results even when an antenna is arbitrarily close to a reflecting surface. This degree of success with the hybrid technique was not anticipated at the start of the work simply because one would not expect an asymptotic (high frequency) method to permit a source current to be placed less than a wavelength or so from a reflection or diffraction point.

The progress on the second item has also been gratifying although it took a different turn than originally anticipated. Initially the work set out to develop a moment method treatment for slot antennas and then to incorporate that single slot treatment into the hybrid technique. However, it was recognized as the work progressed that the moment method technique could also be applied to arrays of slot antennas and so this was pursued. Difficulties were encountered that were eventually overcome and useful results were obtained for small phased arrays that, in our opinion, contribute to the understanding of finite phased array behavior. (Previous work used infinite array models whereas here a finite array model was used.)

Both of these topics contain unanswered research questions which should be pursued in the future. In the case of the first topic dealing with the hybrid technique, a procedure needs to be developed to permit wire antennas modeled using the moment method to be actually mounted on a curved surface with the curvature of the surface being accounted for using the GTD. Further, the limitations on the use of the creeping wave theory in the hybrid technique need to be investigated.

In the case of the second topic dealing with slot antennas, there remains the incorporation of the slot antenna work into the hybrid technique.

Details of both these research topics have not been presented here since they may be found in technical Reports 4372-5 and 4372-7. Our purpose in this final report has been to merely present an overview of the activities and accomplishments of the work on this research program.